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PROTECTION AGAINST FOREST FIRE

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PROTECTION AGAINST FIRE

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CONTENTS

	Page
Brief review of fire situation.....	1395
Objectives in fire control.....	1397
How closely have the objectives been reached?.....	1400
Basic needs in a national fire-control program.....	1403
The essential parts and functions of an adequate fire-control organization.....	1405
Present expenditures for fire control.....	1407
Additional expenditures needed.....	1409
The immediate financial program.....	1412

BRIEF REVIEW OF FIRE SITUATION

The prevention and control of forest fires is a basic requirement in forestry, whether the purpose of management is timber production, watershed protection, or game and recreational development. American forests in every region show the adverse effects of past forest fires, in depleted and decadent stands of the virgin forest, in deteriorated and denuded condition of cut-over lands, in the impaired condition of important watersheds, and in the destruction or marring of scenic values and the destruction of wild life.

There is abundant evidence in every forest region that repeated fires, through an imperceptible process of attrition, have reduced forest stands and in many types the loss has been one third or even one half in value or volume over extensive areas. In some instances repeated fires have converted valuable conifer forests into brush fields, and important hardwood types into ragged forests of unmerchantable trees. The destruction that follows a spectacular crown fire, which takes everything in its path, is readily recognized. The less spectacular light surface fire, if occurring frequently enough, may approach the crown fire in destructiveness to ultimate forest values. In many regions, tree-killing insects and wood-destroying fungi inevitably increase their activity following forest fires. Frequently the problem of protection against future fires is intensified by the very ravages of past fires.

Systematic and organized control against forest fires was begun in many forest regions about 25 years ago. Considerable progress has been made and partial success attained; but taking all the forest regions together, as reflected in the record for 1926-30, the average burned-over area of 41½ million acres annually on national forests, State, and private lands, fire must be considered as a widespread national problem. In table 1 is given the average annual burn of forest lands in the principal regions. This tabulation in part indicates the relative present intensity of the fire problem. These figures, including more than 37½ million acres burned over annually in the South, over 1¼ million acres in the Pacific Coast region, over 1½

million acres in the Central region, and more than half a million acres in the Lake region, conclusively confirm the need for aggressive and intensified effort in curbing forest fires in the United States.

TABLE 1.—Average annual burn on national forest, and State and private forest lands, 1926–30 ¹

Region	Area burned over	Fires ²	Region	Area burned over	Fires ²
	<i>Acres</i>	<i>Number</i>		<i>Acres</i>	<i>Number</i>
New England.....	95, 884	3, 645	Pacific Coast.....	1, 283, 598	6, 898
Middle Atlantic.....	338, 304	6, 557	North Rocky Mountain.....	283, 882	2, 548
Lake.....	563, 536	4, 941	South Rocky Mountain.....	23, 111	1, 289
Central.....	1, 379, 076	12, 527			
South.....	37, 571, 504	117, 778	Total.....	41, 538, 895	156, 183

¹ For unprotected private lands in general only rough estimates are available. Such estimates are however, included in this table.
² Data on number of fires are based on forest area only and are not directly and proportionally comparable to those shown in table 4, of section entitled "Federal Financial and Other Direct Aid to the States", which are based on a total area, including (in addition to all forested lands) some areas that are nonforested.

While the general situation is still critical, it must be noted that there are regions and parts of regions where reasonably adequate fire control obtains, and steady and favorable progress can be recorded in better-stocked and improved forests as a result of favorable public attitude and systematically organized fire control by States, private timberland owners, and the Federal Government.

No forest region is entirely immune from fires. There is, however, great difference in the intensity of the fire problem as between regions and even between parts of the same region. Regions or parts of regions where fires are of infrequent occurrence, or where their spread is promptly checked by natural means, requiring no special organized effort, are excluded from this discussion of the fire-control problem, even though in the aggregate they comprise a large area of commercial timberland. On the other hand important watershed areas needing fire protection are included even if they contain no commercial timber. For these reasons the regional and total areas given in this section of the report are not identical with the areas given in some of the other sections. According to table 2, about 63 percent of the total forest and potential forest land requiring protection against forest fires is actually under some form of protection.

TABLE 2.—National forest and State and private forest areas requiring protection, and total areas protected, by regions (calendar year 1931)

Region	Area re-quiring pro-tection	Area with some form of pro-tection	Region	Area re-quiring pro-tection	Area with some form of pro-tection
	<i>Acres</i>	<i>Acres</i>		<i>Acres</i>	<i>Acres</i>
New England.....	28, 201, 000	¹ 28, 614, 476	Pacific Coast.....	75, 979, 000	70, 160, 372
Middle Atlantic.....	28, 854, 000	27, 723, 539	North Rocky Mountain.....	37, 691, 000	¹ 40, 901, 812
Lake.....	54, 024, 000	¹ 55, 817, 295	South Rocky Mountain.....	28, 070, 000	¹ 29, 397, 458
Central.....	53, 005, 000	16, 665, 330			
South.....	206, 321, 000	51, 476, 910	Total.....	512, 145, 000	320, 757, 192

¹ Excess in area due to discrepancies in reported figures for private forest land.

OBJECTIVES IN FIRE CONTROL

Complete fire exclusion in a forest is rarely attainable. Fires originate from both human and natural causes, and the latter predominate in many localities of the West. The entire elimination of human-caused fires, desirable as it may be, can not be expected in the forest any more than in our homes and cities. Occupancy and use of forest property involves legitimate need for fire, and some fires will escape through carelessness, negligence, or intent. Therefore, in the management of forests, provision must be made to prevent unnecessary fire from starting and for controlling those that through one cause or another do start. What degree of protection against fire is necessary depends on the purposes of management and the damage that may be expected to occur following fires in a given forest type or region.

In other sections of this report the damaging effect of fires on forests is specifically shown. The degree and character of damage varies widely in different forest types. In each forest type, the age of the forest, the amount of debris and slash on the ground, topography, weather conditions, and the season of the year in which the fire occurs, all have a marked influence on the severity of the damage that a given fire may cause. Experience proves that if forests are to be maintained somewhere near their maximum growing capacity, fires must be excluded or held to the lowest possible acreage compatible with the purposes of management for which a given forest is held. One of the major problems in American forestry is to rebuild depreciated forest lands that have already suffered severely from overcutting and burning, and success in recapturing such forest values must be predicated on keeping fires entirely out or within reasonable check. Partial, intermittent, or deferred fire control in forest types where fire damage is severe will at best merely perpetuate partially stocked or unmerchantable forests.

Where timber production is the object of management, it is obvious that a degree of protection must be assured throughout the timber rotation which will prevent seriously reducing the yield or value of the crop. On watershed areas, protection must adequately safeguard the dependent investment throughout its life. In recreational areas, where fires may destroy the unique values, a high degree of protection must be permanently assured even if other resource values would warrant less intensive protection. Fire control is an essential factor in the maintenance of proper environmental conditions for wild life which is one form or another inhabits all forest land.

Protection against fire must be planned on a reasonably permanent basis—half-way measures generally will produce less than half-way results. In most cases, particularly where only a low annual burn can be tolerated, it will be found that the money spent for partial or intermittent protection will be largely a lost and unrealizable investment. The major purposes of management of forest land will be the chief guide in the formulation of the objective in fire control or the limit to which the area annually burned must be held. There are four universal criteria that can be applied as a gage in determining what the objective should be. These are as follows:

1. How much damage will a given fire cause to present and potential timber growth and other forest values?

2. How much damage will a given fire cause to the productivity of the land (the site)?

3. With what degree of difficulty will a forest be reestablished after fire?

4. Will future protection be increased in difficulty after a fire runs over the forest?

These criteria, which reflect the major purposes in all forest management, are interrelated and have been used in this inquiry as a device to measure the degree of damage that a given forest type is likely to suffer as a result of fire. In applying them we frequently find, for example, that a mere surface fire may cause the complete destruction of a spruce or white-pine forest. A fire of moderate intensity in the ponderosa pine type will seriously injure the site, wipe out young reproduction, and take some toll of mature timber. In the hardwood forests of the Central States, a ground fire will usually diminish the growth capacity of the forest and stimulate decay from damaging wood-destroying fungi, seriously depreciating the quality of timber. In the longleaf-pine type, fires do far less damage than in the other types mentioned. A fire in the brush-field watersheds of California seriously threatens storage reservoirs, special spreading grounds, and dependent agricultural land for 3 to 5 years, until a new brush cover returns. In a like manner, the damage done by fire to forage and watershed values, recreation values, and wild life varies between regions and even within a region. These varying factors have been taken into account in the determination of the objective in fire control.

Realizing that complete fire exclusion is not a practicable measure and in many instances is too costly, an objective in fire control has been set up for each forest type based on the percentage of the area that may burn over annually without impairing radically the forest values as determined by the predominant purposes of management. This objective of fire control is expressed as the area of allowable burn, and has been determined for each of the major forest types (table 3). It becomes obvious that the absolute acreage burned over in different forest types is not the sole criterion either of the damage sustained or of how nearly the objective has been met. This annual allowable percentage index has been calculated by considering how the four factors influencing damage from fires operate in the different forest types of the United States. Controlled fires used for definite silvicultural or protective purposes are not included in computing the allowable burn.

From these estimates of allowable percentage of burn in forest types it is possible to compute a percentage for each of the forest regions. Obviously, this composite regional percentage is only a very rough estimate of value and a broad indicator of the goal in view to permit a somewhat more general administrative grasp of the fire situation. Such figures, computed separately for the national forests and for the areas outside, are given in table 4.

TABLE 3.—*Indexes of effective fire control for various forest types*

Type	Annual allowable burn	Type	Annual allowable burn
	<i>Percent</i>		<i>Percent</i>
White pine.....	0.1	Slash pine.....	0.7
Spruce.....	.1	Sand pine.....	1
Douglas fir.....	.2-.3	Longleaf pine.....	3
Larch-fir.....	.25	Northern hardwood.....	.2
Larch-fir-white pine.....	.15	Appalachian hardwood.....	.5
True fir.....	.2-.3	Bottomland hardwood.....	.2
Ponderosa pine.....	.3	Oklahoma hardwood.....	1
Mixed conifers (Calif.).....	.3	Aspen.....	.7
Lodgepole pine.....	1	Noncommercial forests.....	2
Jack pine.....	.5	Brush and nontimbered.....	2.5
Norway pine.....	.3	Watersheds.....	.4-2.5
Shortleaf pine.....	1	Recreation values.....	0.-0.5
Loblolly pine.....	1		

TABLE 4.—*Objectives in fire control on national forest and State and private-forest land, by regions*

Region	State and private areas		National forest areas	
	Area requiring protection	Allowable burn	Area requiring protection	Allowable burn
	<i>Acres</i>	<i>Percent</i>	<i>Acres</i>	<i>Percent</i>
New England.....	27,671,000	0.16	530,000	0.13
Middle Atlantic.....	28,485,000	.35	369,000	.16
Lake.....	52,306,000	.36	1,718,000	.43
Central.....	52,341,000	.59	664,000	.50
South.....	202,904,000	1.34	3,417,000	.90
Pacific Coast.....	41,720,000	.49	34,259,000	.27
North Rocky Mountain.....	9,455,000	1.05	28,236,000	.56
South Rocky Mountain.....	2,194,000	.41	25,876,000	.49
Continental United States.....	417,076,000	.88	95,069,000	.44

The objectives in fire control, as indicated in tables 3 and 4, vary not only from region to region but also for different sections within a given region, as determined by forest type. Thus in New England, whereas only 0.16 percent of the area as a whole can be allowed to burn over annually without seriously or permanently disturbing a growing forest, burns in northern hardwoods may safely reach 0.2 percent, or in noncommercial forest 2 percent. In the South the objective in fire control, expressed as 0.9 percent of allowable burn annually for national-forest areas and 1.34 percent for the territory outside the national forests, may in different types vary from 0.2 to 3 percent. The comparatively high percentage of annual allowable burn in the South is due to the fact that fires in this region affect the forest less harmfully than elsewhere.

As explained previously, these objectives are the best determinable approximations in the light of present information, and are subject to revision as better basic data become available. Differentiations in objectives will undoubtedly be set up as between areas placed under intensive management and culture and those that are to be treated extensively. The trend will very likely be toward higher standards and reduction in the area of allowable annual burn.

HOW CLOSELY HAVE THE OBJECTIVES BEEN REACHED?

The 41½ million acres of forest and potential forest land burned over annually during the period 1926–30, and the 447,000 acres on the more intensively managed national forests included in this total, are startling and alarming figures in themselves. The damage to forest values as a result of these fires can perhaps best be indicated and measured by comparing directly the annual burn and the objectives in fire control set up for each major forest region, as shown in table 5.

TABLE 5.—*Ratio of actual annual burn to allowable burn outside and within national forests, by regions (average 1926–30)*¹

Region	Outside national forests	Within national forests
New England.....	1.84	0.015
Middle Atlantic.....	2.97	3.78
Lake.....	² 2.70	.85
Central.....	5.36	1.03
South.....	14.19	1.02
Pacific Coast.....	4.96	2.78
North Rocky Mountain.....	.99	.87
South Rocky Mountain.....	.56	.70
United States.....	11.00	1.07

¹ A ratio of 1 or less indicates that objective has been reached.
² Data incomplete for certain areas in Wisconsin and Minnesota.

The data briefly indicate that on the 417 million acres constituting the major forest regions, outside of the national forests, requiring protection against fire, 11 times as much damage was done by fire as this area can receive and still retain the desired degree of productivity. On the 95 million acres of national forest land requiring protection as a whole, on the contrary, damage was held down practically to the acceptable maximum. The extremely high ratio (11 to 1) for the areas outside the national forests is due in a large measure to the existence of millions of acres of forest land where, because of lack of funds, no protection is afforded. At the same time, large areas exist in every region where fire-protection work is fairly adequately financed and the results are relatively satisfactory.

Of the territory outside of the national forests (fig. 1) only the South and North Rocky Mountain regions attain their objectives. The forest regions where greater timber values are at stake are burning annually considerably more than the desirable maximum. For example, the South, covering a territory of 206,321,000 acres of forest and potential forest land, is burning over at the rate of 14.2 times its objective, in spite of the fact that the percentage of allowable burn set up in the objective (1.34 percent) is far higher than for any other important forest region. The large area burned over in the South is largely attributable to public indifference to the desire of special groups to fire the woods for one purpose or another, to inadequately financed fire-control organizations, and to the few large sections of the region where no protective effort against fire is being made. But even in forest regions where current expenditures are large, as for example in the Pacific Coast, Lake, or Middle Atlantic, further intensification of fire-control effort is needed if the objectives are to

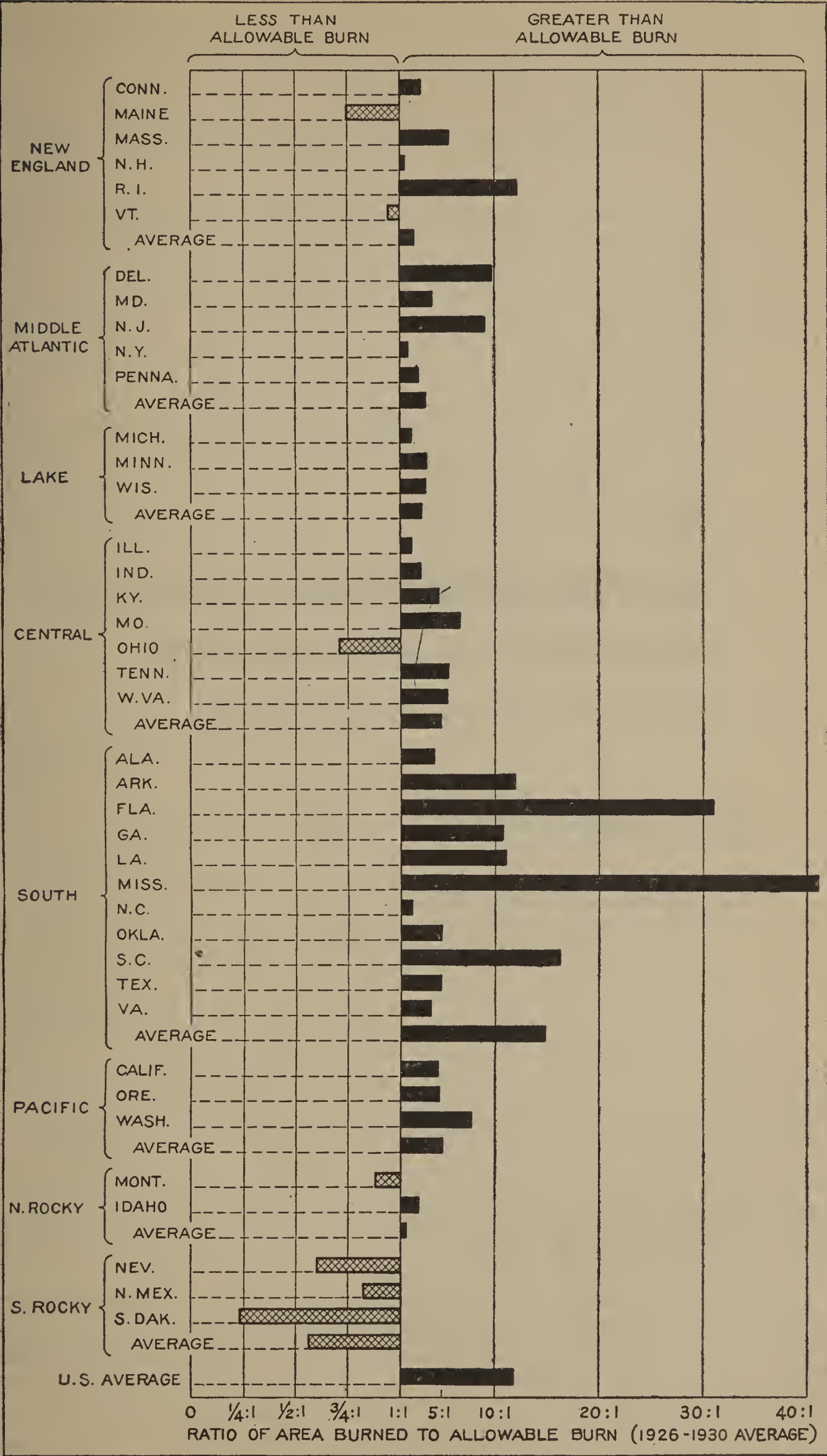


FIGURE 1.—Relation between average annual burn and allowable burn by States, on State and private land. (A ratio of 1:1 or less indicates a satisfactory condition.)

be met. While results on the national forests are on the whole much more satisfactory, examination of groups of critical forest areas (fig. 2) discloses the justification for further intensified effort if the present annual areas burned are to be reduced to the desirable objective. In table 6 are shown the ratios of annual burn to allowable burn on these critical areas for the three regions in which such areas occur.

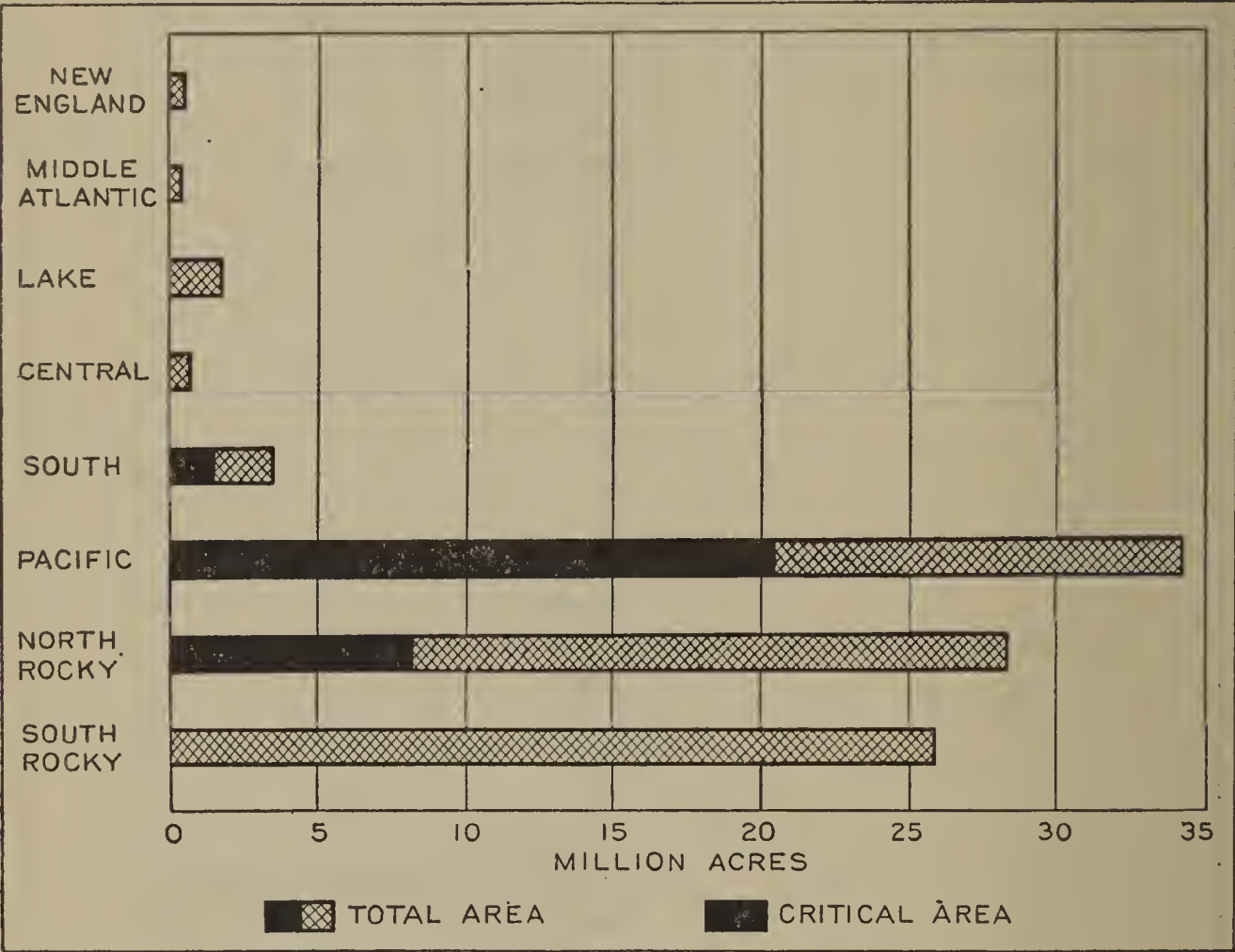


FIGURE 2.—National forest areas needing protection, total and critical areas, by regions.

TABLE 6.—Ratio of actual annual burn to allowable burn on critical areas ¹ in the national-forest system (average 1926–30)

Region	Critical areas	Ratio of burn
	Acres	
South	1, 451, 884	1. 13
Pacific Coast	20, 412, 000	5. 4
North Rocky Mountain	8, 165, 000	5. 5
All areas	30, 028, 884	4. 95

¹ The reference here, as in fig. 2, is to considerable blocks of timber where fire risk is high and need of adequate protection most urgent. Excluded, for the purposes of this discussion, are "spots" or small tracts of high risk, such as may be found in every region.

Thus, of the 95 million acres within the national forests requiring protection, 30 million acres in tracts of considerable size are subject to high fire damage and present an unusually critical fire problem. This 31.6 percent of the national-forest area, during the period 1926–30, suffered 4.95 times the burn set up in the objective.

In the past few years the protective organization in this critical group has been materially strengthened by added man power. im-

proved means and methods of fire fighting, and a road-building program which has made for more rapid and certain suppression of fires. As a result of these additional protective measures a very definite reduction in acreage burned has been accomplished during the past 2 years, and the objectives in fire control have been more nearly approached (fig. 3).

BASIC NEEDS IN A NATIONAL FIRE-CONTROL PROGRAM

The economic necessity for preventing or controlling forest fires is not yet universally recognized or accepted in all forest regions of the

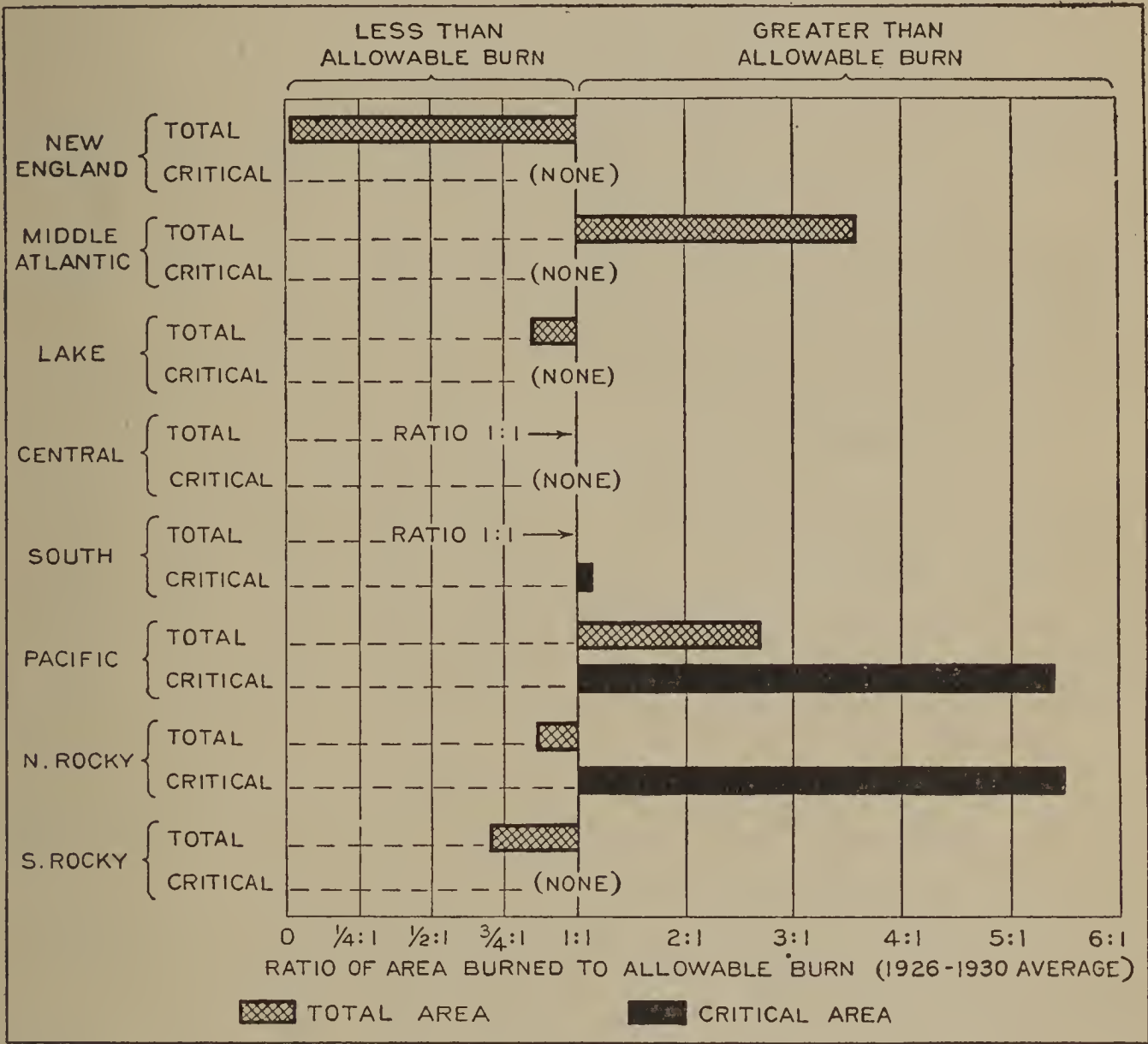


FIGURE 3.—Relation between average annual burn and allowable burn, on total and critical areas of national forests, by regions. (A ratio of 1:1 or less indicates a satisfactory condition.)

United States. In the development of the country, the very process of carving homesteads and farms out of the original virgin forest, the subsequent era of timber exploitation with little or no regard for the destructive methods used, and other unregulated use of our forests have all created an unconscious public attitude of disregard for the forest. Fire was used not only as a means of removing slash and debris but also for the more rapid clearing of standing forests. The habit of firing the woods for one reason or another has persisted in many parts of the United States, although the original purpose or need for doing so as a rule no longer exists. The very extensiveness of the original forests created a false assurance of their inexhaustibility. Thus, through 3 centuries there has grown up a public disregard, dis-

interest, and indifference towards the forests. In spite of 25 years of educational effort the number of human-caused fires is still surprisingly high. We are still confronted with a severe handicap in attempting to protect forests against fires, simply because the public has thus far failed to grasp the nature and extent of the protection problem and accordingly has made little progress toward eliminating the causes of fire. Table 7 showing the number and causes of fires for 1926-30, gives definite evidence of this heedlessness.

TABLE 7.—Average number of fires by cause, national forests, State, and private lands (protected areas only), 1926-30

Region	All causes	Lightning		Railroads		Campers	
	Number	Number	Percent	Number	Percent	Number	Percent
New England.....	3,645	25	.69	683	18.74	87	2.39
Middle Atlantic.....	6,529	35	.54	1,189	18.21	430	6.59
Lake.....	4,941	69	1.40	617	12.49	397	8.03
Central.....	2,882	9	.31	202	7.01	222	7.70
South.....	16,114	177	1.10	833	5.17	1,422	8.82
Pacific Coast.....	6,864	1,612	23.49	339	4.94	670	9.76
North Rocky Mountain.....	2,442	1,527	62.53	150	6.14	175	7.17
South Rocky Mountain.....	1,255	807	64.30	30	2.39	122	9.72
Total or average.....	44,672	4,261	9.54	4,043	9.05	3,525	7.89

Region	Smokers		Debris burning		Incendiary	
	Number	Percent	Number	Percent	Number	Percent
New England.....	1,063	29.16	555	15.23	165	4.53
Middle Atlantic.....	1,830	28.03	820	12.56	414	6.34
Lake.....	1,318	26.67	755	15.28	329	6.66
Central.....	431	14.95	527	18.29	814	28.24
South.....	2,660	16.51	2,327	14.44	4,924	30.56
Pacific Coast.....	1,620	23.60	502	7.31	907	13.21
North Rocky Mountain.....	278	11.38	92	3.77	74	3.03
South Rocky Mountain.....	208	16.57	24	1.91	11	.88
Total or average.....	9,408	21.06	5,602	12.54	7,638	17.10

Region	Lumbering		Miscellaneous		Unknown		Man-caused fires
	Number	Percent	Number	Percent	Number	Percent	Percent
New England.....	25	0.69	365	10.01	677	18.57	99.31
Middle Atlantic.....	40	.61	614	9.40	1,157	17.72	99.46
Lake.....	72	1.46	637	12.89	747	15.12	98.60
Central.....	160	5.55	175	6.07	342	11.87	99.69
South.....	1,067	6.62	1,442	8.95	1,262	7.83	98.90
Pacific Coast.....	337	4.91	774	11.28	103	1.50	76.52
North Rocky Mountain.....	40	1.64	59	2.42	47	1.92	37.47
South Rocky Mountain.....	11	.88	42	3.35			35.70
Total or average.....	1,752	3.92	4,108	9.20	4,335	9.70	90.46

The first task in any adequate fire-control program is to stimulate by carefully designed educational means a proper and sympathetic public attitude towards forest values, and to build up among the leaders of opinion in the community an intelligent understanding of the damage that fires may inflict and the means whereby their destruction may be checked.

The next step in the program, which must be predicated upon an educated public consciousness, involves the enactment of sufficiently stringent local, State, and Federal fire laws providing for the employment of reasonable safeguards in the legitimate uses of fire in the

woods and the punishment of carelessness, neglect, and arson. Forest property, whether in private, State, or Federal ownership, must have legal protection against the careless or recalcitrant fire setter. It is true that even the best forest-fire laws are of little consequence unless there is widespread public support for enforcement. But frequently the apprehension of the vicious or careless fire setter will bring forcibly to a community the first gleam of appreciation of the individual's responsibility for care with fire.

In the main, three different types of thought stand in the way of local progress in fire control in each region, and unless they are recognized and dealt with intelligently, all the physical features of a fire-control program, no matter how well conceived, will fail to insure success. There is first the group that definitely approves the use of fire in the woods and shows antagonism to any fire-prevention program. This attitude is usually founded in ignorance of the ultimate effects of burning or else interest is centered on the advantages to the burner without regard for community welfare. Second, is the group that shows no interest in the effort to halt the setting of fires. Third, are those who may, under careful stimulation, become the leaders in the community's fight against fire, but who at present condone fire setting as a necessary or unavoidable evil. Reasonably suitable fire laws are already on the statute books in practically every important forest region. Here and there they require strengthening, but what is needed above all is an urgent demand from the leaders of thought in each community for their enforcement.

To insure continuous and effective fire control on State and private land, the third step required is organic laws providing for active and positive State responsibility for organizing and directing fire-control effort on a State-wide basis. The States that at present are treating fires as a common enemy and taking the full financial responsibility, without dependence on private funds, are generally showing the best results.

The fourth essential feature in an adequate program of fire control is the establishment of an assured and continuous financial support for building and sustaining the protection organization. In all forest regions funds are required for some or all such specific purposes as fire-prevention programs, competent executives, a trained field force; capital investments for roads, trails, fire lines, lookout houses or lookout towers, and other physical improvements; equipment and tools for prevention and suppression of fires; and special workers for suppressing going fires. Fire fighting is a technical task requiring preparedness, specialized equipment, and an effectively trained organization under a high standard of executive direction. It cannot succeed with haphazard methods; with loose organization; with unskilled leaders hurriedly assembled when an emergency arises.

THE ESSENTIAL PARTS AND FUNCTIONS OF AN ADEQUATE FIRE-CONTROL ORGANIZATION

Speed of attack is the essence of successful fire control in city and forest alike. Once a fire starts it increases progressively in size as long as fuel is in its path and weather conditions are favorable for combustion, and the suppression task becomes progressively more difficult, more costly, and less certain. The ideal protection organ-

ization is built on the principle that fires be discovered and reported promptly to trained fire-fighting units capable of attacking the fire in the shortest possible time and also of expanding to cope with any fire-control job that may develop. The frequency and occurrence of past fires and the rate at which fires spread, as shown by the fire history of a forest property, determine the number and placement of a mobile man power prepared so to function. Provision also must be made for expanding auxiliary forces to supplement the regular first line of defense.

To determine what form the fire-control organization will take and how intensive it will be, full consideration must be given to the local objective in fire control, the intensity and character of fire risks, density of population, accessibility of the areas of greatest fire danger, and the rate at which fires normally spread in a given forest type. The organization thus perfected will function adequately at critical times and will meet definite time requirements as to the speed with which it is prepared to attack a reported fire. On the basis of present studies, speed-of-attack¹ objectives vary all the way from three quarters of an hour to 12 hours.

Just what happens when a fire starts in any area under organized protection? In a critical western forest region the procedure is as follows:

First must come prompt detection furnished by lookout men stationed on prominent peaks or high towers, or at other fire-observation points. The lookout immediately reports the fire to a dispatcher, who in turn transmits the information to a fireman. To make the report requires an extensive communication system of telephone lines in good working order. The fireman, the first line of defense, must be prepared with tools, equipment, horse, or automobile to proceed at once to the fire over roads and trails. If speed is to be made in reaching the fire the road and trail system must break up the territory sufficiently so that fires can be reached in even as small a time interval as half an hour. If the fire requires reinforcements, trucks and additional tools must be dispatched from supply depots and labor sources over a road and trail system. Then comes the task of actually extinguishing the fire, involving exacting standards of performance and management.

In the East as a rule a less elaborate system is needed because the forests usually are more accessible, man power is more readily available, and the difficulties in the way of suppression are not so great.

West or East, the business of controlling fire must be built up step by step to meet each special need. Men, whether hired or volunteer, must be carefully trained for the specialized jobs of fire prevention, including law enforcement, detection, dispatching, fire fighting, and use of various equipment from the simple shovel, ax, and saw to the automatic pumper, plow or tractor. The men must be keenly interested in their tasks, must be skilled in woodcraft, in firefighting, and must be capable of assembling unorganized crews, organizing and directing them, and putting them to work. A skilled fire-control organization in a single Western ranger district must be prepared to suppress a small fire, a broadside of even 100 lightning fires resulting from one electric storm, or a major conflagration requiring the organ-

¹ Allowable time between start of fire and arrival of forces at fire.

ization of a thousand men for a week's battle. Above all else a fire-control organization requires skilled and trained leadership of a high degree of executive and managerial capacity. This highly trained organization requires definite physical things if it is to function properly. It needs for prevention, educational equipment; for detection, lookout structures; for communication, a telephone system; for moving its first line of defense, a road and trail system, adequate transportation, and a supply of carefully selected and in part specially designed equipment; for its second line of defense in isolated regions, supply depots with immense stores of tools, food supplies, equipment, pack stock, bedding, cooking outfits, and trucks.

In forest-fire fighting the plan of organization must provide for the peak year and for the unusual month or day when adverse weather whips fires with fury before it. A year or even a 5-year period may pass by during which even an undermanned or poorly equipped organization can hold fire in check and within the objective of fire control. But the test comes in these occasional bad fire days or the critical fire years when the work of many decades in the protection of the property may be wiped out. Thus protection must be planned for at least the average critical year.

The basic needs for adequate fire control may be summarized as:

1. Comprehensive fire-prevention programs designed to create positive interest and active support on the part of the public.
2. State laws, providing direct State responsibility for the protection of State and private forest lands.
3. Local, State and Federal fire police regulations and laws.
4. Continuing appropriations for capital investments in transportation, detection, and communication system until an adequate layout is provided.
5. Annual appropriations for annual carrying charges to provide capable executives, trained personnel, equipment, and labor for suppressing fires.

PRESENT EXPENDITURES FOR FIRE CONTROL

Inherent regional differences, such as the character of the forest, the terrain, the severity of fire weather, and the local public attitude toward forest property go far toward determining the total expenditures for fire control, but great differences in per-acre expenditures are evident in regions of closely similar fire danger and equal forest values. These differences in current expenditures have in many cases slight relationship to the needs of the job, but often reflect either lack of interest of the State and private owner in the necessity for fire control or their financial incapacity to meet it.

In table 8 are given the current average annual expenditures in fire control by major regions, for all lands in State or private ownership. The expenditures per acre were calculated by charging the total expenditures against the total area needing protection, although in some regions, particularly the Central and South, millions of acres are receiving no protection.

TABLE 8.—Average annual expenditures for fire protection on State and private forest land, and cost per acre, by regions (average 1927–30)

Region	Total ex- penditures	Cost per acre	Region	Total ex- penditures	Cost per acre
	<i>Dollars</i>	<i>Cents</i>		<i>Dollars</i>	<i>Cents</i>
New England.....	535, 440	1. 94	Pacific Coast.....	1, 368, 131	3. 28
Middle Atlantic.....	787, 755	2. 77	North Rocky Mountain.....	558, 105	5. 90
Lake.....	1, 050, 982	2. 01	South Rocky Mountain.....	19, 456	1. 89
Central.....	208, 900	. 40			
South.....	871, 816	. 43	United States.....	5, 400, 585	1. 29

¹ Incomplete record of expenditure on private land in New Mexico.

Of these expenditures, the cost per acre rather than the total is the more significant figure, because it makes possible a better comparison of unit cost. For the territory outside the national forests, present per acre expenditure is highest in the North Rocky Mountain, followed by the Pacific Coast, Middle Atlantic, Lake, New England, South Rocky Mountain, South, and Central regions, in the order named.

The North Rocky Mountain region on the upper end of the scale (5.9 cents) is spending on its total area needing protection almost 15 times as much per acre as the Central and South. This wide spread between regions is not, as stated previously, due merely to differences in the inherent difficulty of the fire-control job but also, and probably more, to the interest or lack of interest of the private landowner and the State in fire control and the amount of money they are willing to spend for such activities. As will be shown later, present expenditures fall considerably short of the needs in every forest region and, largely, in proportion to the excess in the ratio of present burned-over acreage to the desired objective in allowable annual burn.

In the national forests, where the fire-control problem has been progressively met with increased appropriations for intensified protection effort, present expenditures for the whole national-forest area more nearly approach ultimate needs. But even here, as indicated in table 6, about 30 million of the 95 million acres requiring protection are still burned over to a considerably greater degree than the objective set up, and in these areas protection costs must be materially increased.

The present per-acre costs for all national forests given in table 9 are very much higher than per-acre costs on State and private land, but they include every direct and indirect item of expenditure. The lowest costs per acre are found in the South Rocky Mountain and New England regions and the highest in the Central and the South. The high costs in the latter regions are in part due to the fact that the units protected are comparatively small and require protection against threatening fires from outside areas which are frequently costly to handle. These costs will be reduced as additional territory is added to round out these properties. The higher costs in the Pacific Coast and North Rocky Mountain regions reflect the difficulties of fire control in highly inflammable forests on adverse terrain.

TABLE 9.—Average annual costs of protection on national-forest areas and cost per acre by regions (average 1926–30)

Region	Total cost	Cost per acre	Region	Total cost	Cost per acre
	<i>Dollars</i>	<i>Cents</i>		<i>Dollars</i>	<i>Cents</i>
New England.....	21, 476	4. 05	Pacific Coast.....	2, 569, 394	7. 50
Middle Atlantic.....	28, 525	7. 73	North Rocky Mountain.....	1, 917, 266	6. 79
Lake.....	95, 472	5. 56	South Rocky Mountain.....	419, 553	1. 62
Central.....	68, 156	10. 26			
South.....	317, 756	9. 30	Total.....	5, 437, 598	5. 72

In table 10 the regional costs for the protection of national-forest areas are segregated by the major elements. It will be noted that the annual carrying charges and maintenance of improvement roads and trails forms a large item of the fire-control costs in the national forests, because vast inaccessible areas have to be broken up with a transportation system for the movement of men and supplies. In contrast to this, much of the territory outside of the national forests is in the more settled and developed sections, where existing roads already furnish the basic transportation system. Besides, new roads in private and State protective units, even where their use for protection is important, are, as a rule, built chiefly for such uses as inter-community travel and utilization and thus are not ordinarily included in fire-control costs.

TABLE 10.—Annual cost of fire control on national forests, by regions (average 1926–30)

Region	Prevention and presuppression	Improvements—roads, trails, and other ¹	Fire suppression	Total
New England.....	\$8, 411	\$795	\$12, 270	\$21, 476
Middle Atlantic.....	7, 640	3, 026	17, 859	28, 525
Lake.....	39, 400	28, 222	27, 850	95, 472
Central.....	30, 640	14, 077	23, 439	68, 156
Southeast.....	138, 069	54, 845	124, 842	317, 756
Pacific Coast.....	863, 981	853, 049	852, 364	2, 569, 394
North Rocky Mountain.....	577, 468	759, 548	580, 250	1, 917, 266
South Rocky Mountain.....	138, 539	67, 278	213, 736	419, 553
Total.....	1, 804, 148	1, 780, 840	1, 852, 610	5, 437, 598

¹ Annual carrying charges.

Recognizing that per-acre costs will vary with the difficulty of the fire-control job and the skill with which the work is done, and that these differ between regions, the inescapable conclusion must be drawn that in the main, where present burned-over areas materially exceed the objective, the present scale of expenditures is inadequate.

ADDITIONAL EXPENDITURES NEEDED
ON THE NATIONAL FORESTS

During the past decade, painstaking studies of physical factors and critical investigations of organization and methods have been made for the national forests to determine both the needs and costs of an adequate fire-control system. There is now in progress an additional

series of transportation, detection, and organization studies which seeks to supply in detail what ultimate expenditures may be required for each national forest to meet its objective in fire control. This material as far as it has been available has been used as a guide in arriving at the proposed new schedule of costs. Additional expenditures have been considered only for those national forests where the objective in fire control has not been met or where additional capital outlay promises to result in a net reduction either in costs of fire suppression or in damage to forest values. The great bulk of the proposed increased expenditures as shown in table 11 is almost wholly for the 31.6 percent of the national-forest area classed as critical and now suffering from severe losses.

In examining the figures in table 11, it will be noted that increased expenditures are not contemplated in two regions, are less than 1 cent an acre in 2 others, between 1 and 1.5 cents in 3, and approximately 2 cents in 1. Of the increases proposed at least 74 percent is for the cost of additional roads and trails and includes capital investment and maintenance. In several instances the additional mileage is needed because of the expanding area of the national forest as the units are built up by additional land purchases, and, in the case of the South Rocky Mountain region, to reduce fire-suppression costs. Since the present net area was used to arrive at the annual charge per acre for carrying the investment in transportation, the figure will become less and less as the purchase program is completed. It will be noted that in five regions the additional expenditure for roads and trails will make possible reductions in present costs to the point where the total additional is less than the transportation increment.

TABLE 11.—*Present and proposed annual costs per acre for adequate fire control on the national forests*

Region	Present costs	Proposed costs	Total additional	Proposed for roads and trails ¹
	<i>Cents</i>	<i>Cents</i>	<i>Cents</i>	<i>Cents</i>
New England.....	4.05	4.05		
Middle Atlantic.....	7.73	8.61	² 0.88	1.1
Lake.....	5.56	7.035	1.475	1.647
Central.....	10.26	11.378	1.118	1.52
South.....	9.30	10.33	1.03	1.6
Pacific Coast.....	7.50	9.823	2.323	1.564
North Rocky Mountain.....	6.79	7.59	.8	.6
South Rocky Mountain.....	1.62	1.56	(3)	.025
Average (weighted).....	5.72	6.853	1.150	.851

¹ Capital investment and maintenance.
² Additional expenditure for better transportation will make possible a reduction of present cost in other particulars, resulting in a "total additional" cost actually less than that proposed for roads and trails.
³ Slight additional expense for roads and trails would result in a saving of 0.06 cents per acre.

ON STATE, PRIVATE, AND OTHER AREAS OUTSIDE NATIONAL FORESTS

The ultimate costs of fire control for areas outside of the national forests, while not as readily ascertainable as those within, are based on careful estimates made in 1930 by the Forest Service cooperating with the States. The estimates have subsequently been checked against comparable costs on national forests in the same regions with due allowance for differences in accessibility and fire danger. These comparisons indicate that, in order to attain the fire-control objective

set up in this discussion on the present area of State and privately owned forest land within the next 10 or 15 years, an annual expenditure of about \$20,000,000 would be required, or the per-acre costs shown in table 12.

TABLE 12.—*Estimated present and proposed costs per acre of fire control on areas in State, private, and other ownership outside national forests*

Region	Present costs ¹	Ultimate costs	Total additional
	<i>Cents per acre</i>	<i>Cents per acre</i>	<i>Cents per acre</i>
New England.....	1. 94	2. 86	0. 92
Middle Atlantic.....	2. 77	3. 35	. 58
Lake.....	2. 01	4. 24	2. 23
Central.....	. 40	2. 55	2. 15
South.....	. 43	5. 43	5. 00
Pacific Coast.....	3. 28	6. 43	3. 15
North Rocky Mountain.....	5. 90	8. 39	2. 49
South Rocky Mountain.....	2. 89	1. 39	3. 50

¹ Present costs were calculated by charging the total expenditures against the total area needing protection although in the Central and South regions many million acres are entirely unprotected.
² Incomplete record of expenditure on private land in New Mexico.
³ This figure subject to change as more complete records of current expenditures become available.

The estimate is not final and is subject to further revision as better data become available. In the course of time, as antifire sentiment increases, the cost of protection may be expected to decrease. On the other hand, the areas of forest and potential forest land as estimated in 1930 will undoubtedly have to be increased in future calculations because of additions from farm-land abandonment. It should be noted that these costs, in contrast to those for national forests, include only small present or proposed expenditures for roads or trails. In the main, such items will be financed, as in the past, out of highway and road appropriations as the need for additional community and State roads arises; whereas, on the national forests the cost of protection for roads is specifically provided for by Congress.

For the South region it has been extremely difficult to estimate the cost of adequate protection because of lack of information on the huge area now entirely unprotected. The \$11,000,000 estimated for this region therefore must necessarily be regarded only as a reasonable approximation of ultimate cost if the total acreage given in table 4 were to be adequately protected. The task is, however, so great, and the probability of protection being given to the entire area is so uncertain, that if \$6,000,000 were to be set up as the goal, it would more nearly represent the possibilities of attainment in the next 15 to 20 years.

The data in table 12 indicate needed increases in every region varying from 5.8 mills per acre in the Middle Atlantic region to 5 cents in the South. Relative increases are even more striking. In the South, where it has already been shown that the burned-over area is 13.8 times the ultimate objective, annual expenditures would have to be increased at least twelvefold if the total acreage were to be put under adequate control. In the Pacific Coast region, where the burn is five times the objective, double the present expenditures will be required.

In contrast with the estimate of \$20,000,000 required for adequate protection of areas outside of the national forests, total expenditures

from all sources have averaged about \$5,400,585 for the period 1927-30, and reached \$7,220,871 in 1931 (table 13). This wide spread between actual expenditures and needs is significantly reflected by the conditions in the South, where current expenditures are slightly under \$944,000 a year and the requirements of the job as indicated in this study are more than \$11,000,000; and in the Pacific Coast region and the Lake region where 1931 expenditures were over half a million less than the ultimate required amount.

TABLE 13.—*Total present and estimated ultimate annual cost of adequate fire control on areas outside national forests*

Region	Present ex- penditure ¹	Ultimate cost
	<i>Dollars</i>	<i>Dollars</i>
New England.....	511, 331	792, 000
Middle Atlantic.....	² 1, 165, 859	955, 000
Lake.....	1, 668, 788	2, 219, 000
Central.....	250, 278	1, 337, 000
South.....	943, 955	³ 11, 018, 000
Pacific Coast.....	2, 059, 637	2, 684, 000
North Rocky Mountain.....	603, 863	793, 000
South Rocky Mountain.....	17, 160	30, 500
Total.....	7, 220, 871	19, 828, 500

¹ The costs which are for the calendar year 1931 vary considerably from average expenditures over the 5-year period 1926-30, upon which the per-acre costs in table 12 are figured. Nevertheless they serve to illustrate in several of the regions that "ultimate cost", or the desired annual expenditure may often be little more than the unavoidable expenditure in any one year, resulting from large suppression expenditures.

² The increase in present expenditure over ultimate cost for the Middle Atlantic region is explained by the occurrence of an unusually bad fire season in 1931, calling for greater than average suppression costs. Reference to table 12 will make it clear that ultimate costs are reckoned as at least one fifth higher per acre than average present costs.

³ Based on the supposition that the total areas given in table 4 is to be given protection.

Expenditures during the fiscal year 1932 in areas outside the national forests were shared by the private owners of land, the Federal Government (through the Clarke-McNary Act), and the States in approximately the following proportions: by private owners, 18 percent; by the Federal Government, 26 percent; and the remainder, or 56 percent, by the States.

THE IMMEDIATE FINANCIAL PROGRAM
OUTSIDE NATIONAL FORESTS

The basic steps in a fire-control program have been discussed. If forests and watersheds are to be made reasonably safe against further ravages of uncontrolled fires, and if the required objectives in fire control are to be reached within reasonable time, honest recognition must be given to the fact that more money is needed for the job.

Total and present expenditures for areas outside the national forests, as given in table 13, indicate the need of greatly increased fire control expenditures in order to bring fire losses down to an acceptable figure. All participating agencies, Federal, State, and private, should contribute more than at present and the total should be increased as rapidly as the funds can be used efficiently. The Federal appropriation for the fiscal year 1933 is only \$1,611,580 although the Clarke-McNary Act authorizes an annual appropriation of \$2,500,000 for this purpose. Further discussion of principles and policies which

should govern Federal participation in this work will be found in the section of this report entitled "Federal Aid to States and Private Owners."

ON NATIONAL FORESTS

The increases needed per acre on the national forests, as given in table 11, represent an objective to be attained not later than the end of the next 10-year period. To this end the following program is offered:

1. Roads and trails—annual program for 10-year period (this includes maintenance)-----	\$3, 700, 000
2. Other improvements such as telephone lines, lookout structures, etc., annual program for 5 years, including maintenance and replacement-----	780, 000
3. Increased man power—starting with an addition of \$80,000 to present appropriation during the fiscal year 1934 and increasing to \$625,000 at the end of the 8-year period when the road and trail program approaches completion and the construction crews will not be available for fire control work-----	80, 000–625, 000

These items cover the investment that should be made for the required transportation system, the physical plant, the essential equipment, and additional man power. In comparing the proposed expenditures for roads, trails, and other improvements with the costs per acre given in table 11 it is necessary to remember that this class of expenditures represents a capital investment from which the annual cost is obtained by amortization. For example, it is estimated that protection roads will last, on the average, 40 years, and the construction cost is therefore charged off over a 40-year period.

The need for increased man power will become acute as the road and trail and improvement jobs near completion and this source of labor is moved out of the country, and this explains the considerable annual increases in present funds appropriated for fire control up to a total increase of \$625,000 as the road program approaches completion. To balance this expenditure, however, an annual saving of some \$600,000 in fire-fighting costs may be expected as the system reaches completion.

IN NATIONAL PARKS AND NATIONAL MONUMENTS

According to information supplied for this report by the National Park Service there are 8,426,046 acres in national parks and monuments, including parks and monuments in Alaska and Hawaii. Much of this area is susceptible to damage from forest fires. The average annual expenditure for fire suppression for the 6 fiscal years 1927 to 1932, inclusive, was \$95,324.85, and the average area burned annually during the last 5 calendar years, 1927–31, was 19,072 acres.

The Park Service estimates that the following additional capital investment in fire protection improvements is needed, the investment to be made over a 5-year period:

Lookout houses and towers-----	\$48, 600
Telephone lines-----	42, 327
Tool kiosks and tool houses-----	18, 550
Guard cabins and barns-----	18, 925
Roads-----	65, 000
Trails-----	284, 772
Water development-----	3, 950
Grand total for 5-year period-----	482, 124

This would mean an annual expenditure of \$96,425 for this period.

The Park Service estimates that a total of \$63,214 is needed annually for fire prevention services and maintenance.

This amount added to the annual expenditure of the 5-year protection improvement program gives a total of \$159,639 which is the average annual fire protection expenditure estimated as necessary by the Park Service.

ON INDIAN FOREST LANDS

It has been estimated that approximately 9 million acres of the Indian lands is actually forested out of a total of 7½ million acres, and 8 million acres, respectively, of commercial and noncommercial forest land. The Director of Forestry in the Office of Indian Affairs has supplied for this report the following data on forest fires on Indian lands.

The average annual expenditure for fire control during the 6 fiscal years 1927-1932, inclusive, was \$94,528. During the same period the average area burned annually was 85,563 acres. The allowable burn is 40,000 acres annually and the estimated annual expenditure needed to bring the burned acreage down to this figure is \$450,000 including fire prevention, fire suppression, roads, trails, telephone lines, look-outs, and other fire protection improvements. This large increase is largely for capital investments.

PUBLIC DOMAIN

At the request of the Commission appointed by President Hoover to make a study and report with recommendations for the solution of the public-domain problem, the Forest Service in 1930 made an estimate of the cost of fire protection for this land. The following acreage and costs are taken from the Forest Service report.

The total area of the public domain is given as 173,318,246 acres, of which 32,244,263 acres is considered as needing some degree of fire protection. On some of this land, as for example the piñon and juniper foothills in the West, the fire danger in many places is very low. The timber values and watershed values are also comparatively low in some cases. The cost estimates consequently are low compared with actual costs on high-value and high-danger forest lands.

It is estimated that the cost of adequate protection of this 32,244,263 acres will amount to \$723,598. This estimate is based on national-forest standards of protection and assumes that wherever the public domain forms logical parts of the national-forest system these areas will be added to the existing national forests and administered as a part of them. This of course would facilitate administration and reduce the cost of protection. Separate administration undoubtedly would increase the total cost above the estimate given. Further and more detailed discussion of the public domain will be found in the section of this report entitled "Public Domain and Other Federal Forest Land."